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Study on rock pressure activity regularity of large mining height work face in Cha Ha-su coal mine[1]

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Abstract. This article aims to study on the pressure activity regularity of large mining height work face in weakly cemented strata, the 3101 work face was used to example, according to field test monitor, the pressure activity regularity of work face was analyzed, and the applicability of scaffold was studied. The results show that the working surface had obvious pressure characteristics, the first interval of pressure average was 35 m, the interval of periodic pressure average was 16.6 m, the sustained distance of pressure average 5.9 m; during the first pressure working resistance of support was between 12365.3 kN and 10197.6 kN, the dynamic load coefficient was 1.59 − 2.16, during the periodic pressure working resistance of support was between 8953.5 kN and 12553.5 kN, the dynamic load coefficient was 1.4 − 1.87; along the declining direction of the working face, support load distribution was arched; force of support had normal distribution during mining. The field pressure data showed that the design of the ZY12000/28/63 type shield hydraulic support was reasonable and reliable.

Key words. Large mining height work face, weakly cemented strata, rock pressure activity regularity, working resistance..

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1. Introduction

The widely occur the Jurassic coal measures strata in northwest of China, the type strata has characteristics of low strength, poor cementation and collapse under the influence of water, easy weathering, the physical and mechanical properties of weakly cemented rock have obvious differences with rock of middle because of weak cemented formation conditions of natural endowment determines, mining practice shows that pressure activity regularity of large mining height work face in weakly cemented strata also have certain differences with Middle East mine [1], [2].

Over the years, the majority of mining workers and designers are working for the core issues of surrounding rock control, that is solving the working resistance of supports. It has been widely studied and proposed. The method for calculating the resistance of support under given deformation and given load was put forward. It is difficult to accurately express the relationship between support and surrounding rock, and to grasp load size and source from the main roof. In the actual design process, the empirical method and the estimation method are still used to determine the working resistance of the support. Sometimes blindly choice of large support working resistance may cause increase in the cost of support.

Due to understanding properties of weakly cemented strata and mine pressure regularity was not clear, during mining of large mining height work face in weak cemented strata, accidents of large area roof caving, subsidence, collapse water sand, steps crushing were frequent occur [3]–[6]. Since 2000, mining height of large mining height work face are broken raised from 4.8 m to 8.0 m in China's, the support working resistance was increased linear basically, but the safety accidents were occurred frequently for large mining height in the weakly cemented strata in the western mine, it further illustrated the equipment of support the applicability under the condition of weak cementation strata cannot adopt by the traditional design method of calculation and evaluation. Many scholars had studied on the large mining height strata structure evolution, support working resistance calculation, three zones distribution, and so on [7]–[10]. The 3101 work face of large mining height was the engineering background in Inner Mongolia erdos area in this paper, according to the method of in-situ test, the mine pressure activity regularity was analyzed, the applicability of the stents was evaluated.

2. Structure and function of electromagnetic-hydraulic composite brake system

3101 work face was first mining face in Cha Ha-su coal mine, the mining coal seam of work face was $3-1$, the depth of work face was 400 m, the mining length was 2500 m long and tendency length was 300 m. Average thickness of coal seam was 5 m, dip Angle of coal seam was 1°, and nearly horizontal. Once mining overall height of large mining height comprehensive mechanized mining technology are broken, ZY12000/28/63 type shield hydraulic support was selected, the support working resistance was 12000 kN, rated initial support was 31.4 MPa, center distance of support was 1.75 m.

Strata structure was simple and monoclinic structure. immediate roof was sandy mudstone and shale interbred, average thickness was 5.3 m, main roof include medium grained sandstone, fine grained sandstone and sandy mudstone, average thickness respectively were 22.7 m, 1.4 m and 28 m; immediate floor include mudstone and carbonaceous mudstone, thickness was 1.23 m, main floor was coarse grained sandstone, thickness was 9.2 m. Top uniaxial compressive strength of roof rock between 10 and 33.7 MPa, uniaxial compressive strength of floor rock between 32.6 and 36 MPa, therefor, rock strength was lower.

3. Pressure activity regularity of work face

There were 172 hydraulic supports in 3101 work face, and in order to analysis pressure activity regularity, the work face was divided into three parts in this paper.

Pressure criterion of working face can be expressed as

$$P_{\mathrm{t}}^{/} = \overline{P_{\mathrm{t}}} + \sigma_{\mathrm{p}}\,, \tag{1}$$

$$\sigma_{\mathrm{p}} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_{\mathrm{t}i} - \overline{P_{\mathrm{t}}})^2}\,, \tag{2}$$

where $P_{\mathrm{t}}^{/}$ is pressure criterion of working face; σ_p is the mean square deviation of the end cycle resistance of the support; n is cycle times of support; $P_{\mathrm{t}i}$ is the end cycle resistance of the support; $\overline{P_{\mathrm{t}}}$ is the average end cycle resistance of the support.

Dynamic load coefficient of support can be expressed as

$$K_{\mathrm{D}} = \frac{P_{\mathrm{ly}}}{\overline{P_{\mathrm{t}}}}\,, \tag{3}$$

where K_{D} is dynamic load coefficient, P_{ly} is the average resistance of the support during pressure, $\overline{P_{\mathrm{t}}}$ is the average resistance of the support during normal mining.

3.1. Pressure interval of work face

The press of first pressure was emerged from up to down in the work face, and the pressure interval was between 32.1 m and 38.7 m, the average pressure interval was 35 m. During pressure monitoring of the face, the pressure of work face occurred 20 times, periodic pressure interval was between 10.5 m and 22.2 m in the upper face, the average value was 16.6 m, the sustained distance of pressure average was 5.85 m; periodic pressure interval was between 10 m and 23.5 m in the middle face, the average value was 16.6 m, the sustained distance of pressure average was 5.9 m; periodic pressure interval was between 10.5 m and 22.5 m in the lower face, the average value was 16.6 m, the sustained distance of pressure average was 5.9 m; the average pressure interval was 16.6 m, and average sustained distance was 5.9 m.

Table 1. The first pressure interval of work face

Area of work face	Support number	Pressure interval, m
the upper	23#	32.1
	35#	32.1
the middle	80#	34.5
	88#	34.5
the lower	143#	37.9
	151#	38.7
Average value		35

Table 2. The first pressure interval of work face

Area of work face	Support number	Pressure interval, m	Average value, m	Sustained distance of pressure, m
the upper	23#	12.5-22.2	16.6	5.4
	35#	10.5-19.8	16.6	6.3
the middle	80#	10.5-23.5	16.2	5.9
	88#	10-23.5	17	5.9
the lower	143#	10.5-25.5	16.4	6
	151#	10.5-22	16.8	5.8
Average value			16.6	5.9

3.2. Support working resistance and pressure strength

It was seen from Fig. 1 that support working resistance were 12365.3 kN and 12214.5 kN during first pressure on the upper, average value were 10866.7 kN and 11784.2 KN, dynamic load coefficient were 1.7 and 1.88 respectively; Support working resistance were 10197.6 kN and 10197.6 kN during first pressure on the middle, average value were 10197.6 kN and 11770.5 kN, dynamic load coefficient were 1.59 and 1.84 respectively; Support working resistance were 10829.1 kN and 10829.1 kN during first pressure in the lower, average value were 10157.6 kN and 10044.5 kN, dynamic load coefficient were 1.67 and 2.16 respectively; during the beginning of mining work face the average support working resistance between 5661 and 6432 kN, it was $47 - 54\,\%$ of the rated support working resistance.

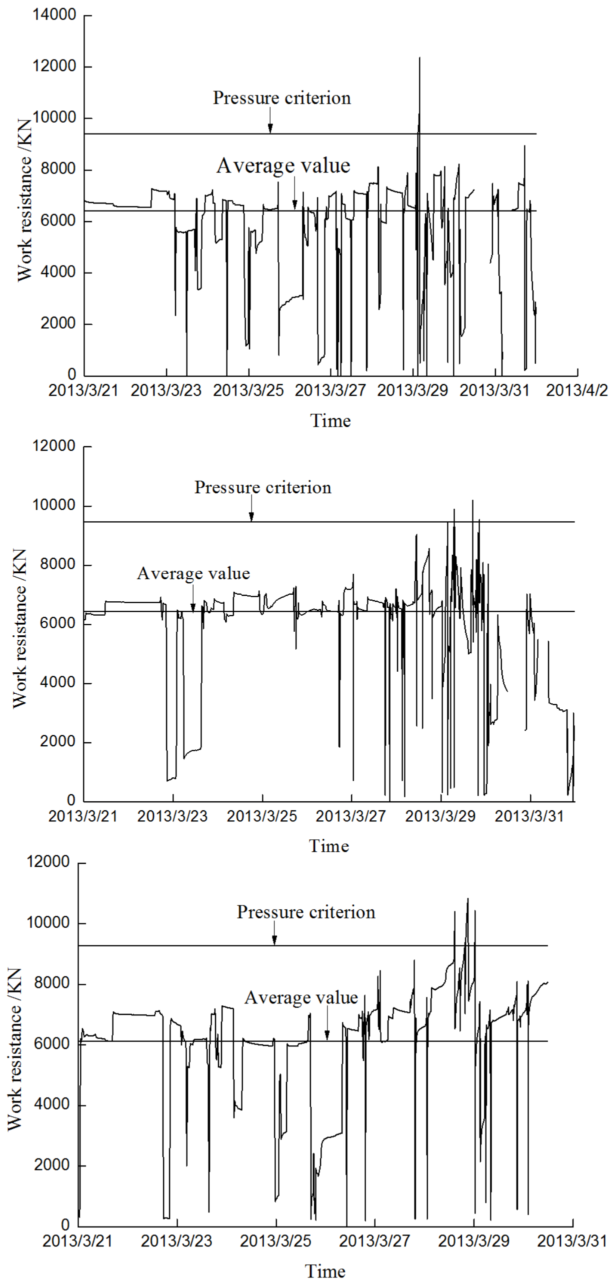

Fig. 1. The support working resistance during first pressure: (a) 25# support of lower work face; (b) 81# support of middle work face; (c) 145# support of middle work face

It was seen from Fig. 2 that support working resistance were 8953.5 kN and 12553.5 kN during periodic pressure on the upper, average value were 10469.3 kN and 11002.9 kN, dynamic load coefficient were between 1.4 and 1.87, average value was 1.7; support working resistance were 9151.5 kN and 12158 kN during periodic pressure on the middle, average value were 9553.2 kN and 10099.7 kN, dynamic load coefficient were between 1.35 and 1.67, average value was 1.54; support working resistance were 8604.8 kN and 12534.9 kN during periodic pressure in the lower, average value were 11205.7 kN and 9727.1 kN, dynamic load coefficient were 1.3 and 1.83, average value was 1.53; during this mining of work face the average support working resistance between 6190 and 7524 kN, it was $52 - 63\,\%$ of the rated support working resistance.

3.3. Distribution characteristics of support working resistance

Support working resistance distribution was normally distributed characteristics, the support working resistance distribution of six group support were the largest proportion within the range of 6000 KN to 8000 KN, rate were 43.6%, 27.4%, 52%, 37.5%, 48.1%, 50.1% respectively, the whole face an average was 43.12%; if support working resistance was defined as low resistance area within the range of 0-4000 kN, 4000 kN to 80000 kN as normal resistance area, $>$ 8000 kN as high resistance area, it was concluded that support working resistance low resistance area distribution frequency was 8.1%, normal resistance area distribution frequency was 59.6%, high resistance distribution frequency was 32.3%, more than 12000 kN support working resistance was only 1.2%, so the hydraulic support normal played a supporting role, as shown in Fig. 3.

Through the in-situ test, face support working resistance of 3101 work face only individual support more than the rated resistance during mining, more than range was $0.06\,\%k - 0.06\,\%$, not more than the 15 %; support working resistance distribution in accord with normal distribution characteristics, most of the work resistance within the scope of the normal resistance, accounted for 59.6 %, high resistance area accounted for 32.3 %. ZY12000/28/63 type hydraulic support is reasonable in the 3101 work face, it ensured the safety during work face mining. Now Cha Ha-su coal mine has safety mining the third 3-1 coal seam work face with this type hydraulic support.

3.4. Influence of mining height on working resistance of support

As it is known, with the increase of mining height, the volume of mined out area becomes larger and filling the mined out area requires thicker roof rock. The load of the support consists of two parts, the direct load and the additional load produced by the main roof motion. That will cause greater direct roof load when larger mining height.

According to the above analysis, the load on the top of the working face can be

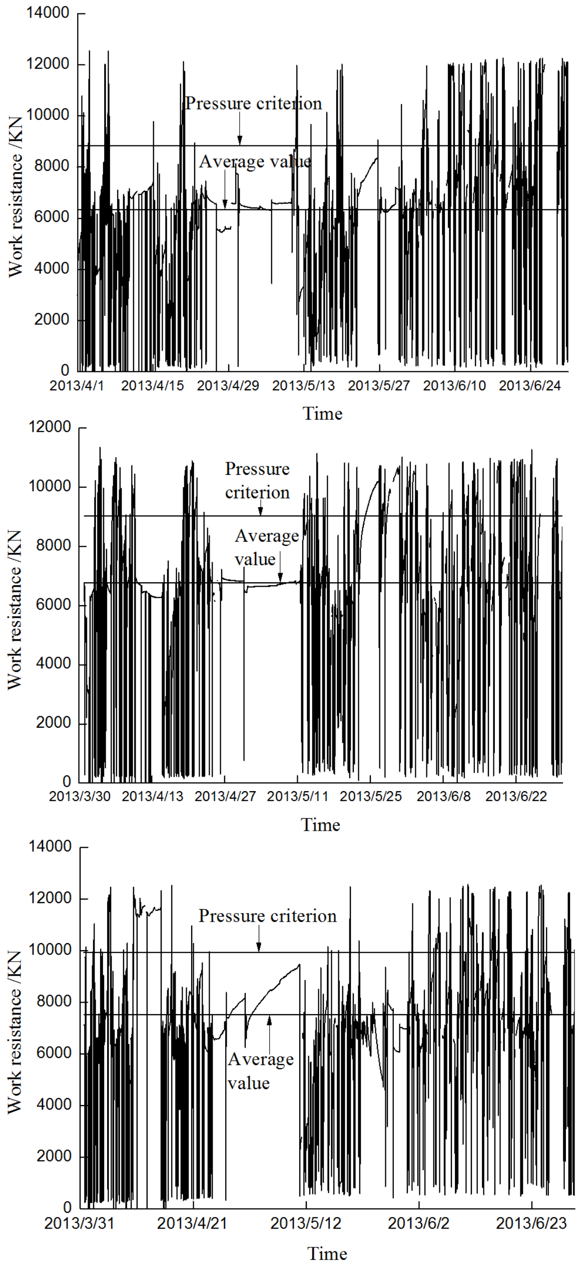

Fig. 2. The support working resistance during periodic pressure: (a) 25# support of lower work face; (b) 81# support of middle work face; (c) 145# support of middle work face

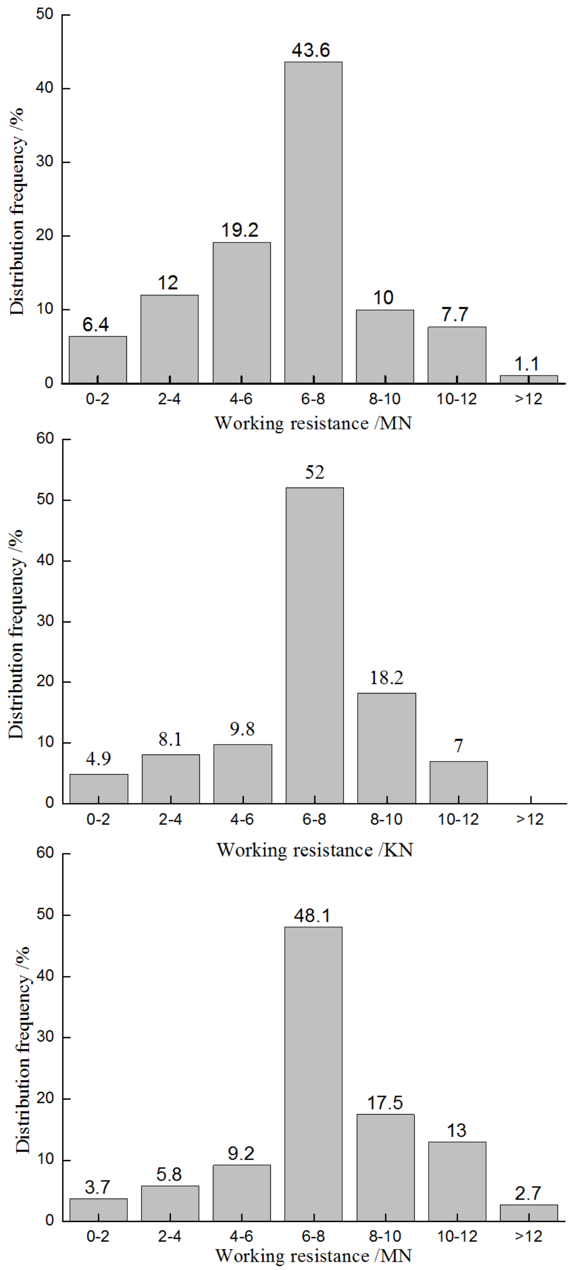

Fig. 3. The distribution frequency of support working resistance: (a) 25# support of lower work face; (b) 81# support of middle work face; (c) 145# support of middle work face

expressed as

$$w = (2-4)ldM\gamma\,, \tag{4}$$

where W is weight of direct roof (kN); l is length of direct roof (m); d is width of direct roof (m); M is mining height (m); γ is bulk density (kN/m^3).

The given load on main roof can be expressed as

$$P_{\mathrm{d}} = \frac{EL^2 d\cos\alpha\cos(\theta-\theta_1)}{2\sum h}\,, \tag{5}$$

where P_{d} is given load on main roof (kN); E is rock elastic modulus (MPa); L is broken length of main roof (m); θ is revolution angle of main roof (°); θ_1 is revolution angle of roof bottom (°); α is rock fracture angle (°); $\sum h$ is thickness of main roof (m).

The maximum load of the bracket is

$$Q_{\max} = W + P_{\mathrm{d}}\,. \tag{6}$$

Substitute the relevant parameters to formula (5), the given load is inversely proportional to the direct roof thickness. When the thickness of direct roof is larger than 4 m, the given load increase small amplitude, as shown in Fig. 4.

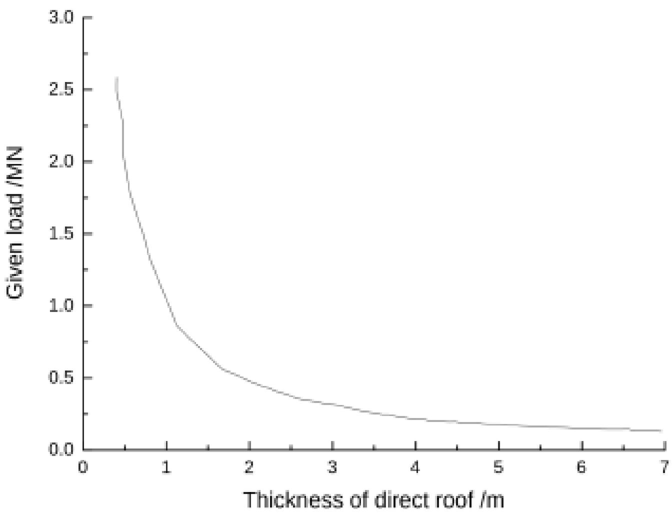

Fig. 4. The distribution frequency of support working resistance

4. Conclusion

1. The working surface had obvious pressure characteristics, the first interval of pressure average was 35 m, the interval of periodic pressure average was 16.6 m, the sustained distance of pressure average 5.9 m;

2. Support working resistance were between 8953.5 kN and 12553.5 kN during pressure of work face, dynamic load coefficient were between 1.4 and 2.16, the resistance was basic in the scope of the rate work resistance.

3. Support load distribution of work face had the characteristics of normal distribution, the support force was reasonable, the in-situ test data further proved that the working face support selection was reasonable and reliable.

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